# ADVANCED TRENDS IN BIOMEDICAL ENGINEERING

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***Abstract:*** **Biomedical Engineering is the application of engineering sciences to medicine and biology. The only fixed aspect of today's science is the rapid change. Reviewing what is new has a unique importance, since the researcher and the practitioner needs to update his/her knowledge. This paper aims to present the main advanced trends among the majority of the fields within the biomedical engineering. They have been reviewed, the trends in medical imaging, biomechanics, biomaterials, biosensors, bioinstrumentation, rehabilitation engineering and clinical engineering.**

**It is recommended, to review the all the trends in the discipline and determine the opportunities for the researchers and the practitioners.**

## I.INTRODUCTION

"Biomedical engineering is a discipline that advances knowledge in engineering, biology and medicine, and improves human health through cross-disciplinary activities that integrate the engineering sciences with the biomedical sciences and clinical practice. It includes**:**

1. The acquisition of new knowledge and understanding of living systems through the innovative and substantive application of experimental and analytical techniques based on the **engineering** sciences.

2. The development of new devices, algorithms, processes and systems that advance Biology and medicine and improve medical practice and health care delivery."

It is the definition of the imperial college for the biomedical engineering. (Imperial college, 2008) Many definitions are introduced for the biomedical engineering. The national institute of biomedical imaging and bioengineering (NIBIB), which is affiliated to the National Institute of Health (NIH), has coined this definition:

""Biomedical Engineering integrates physical, chemical, mathematical, and computational sciences and engineering principles to study biology, medicine, behavior and health. It advances fundamental concepts, creates knowledge from the molecular to the organ systems levels, and develops innovative biologies, materials, processes, implants, devices, and informatics approaches for the prevention, diagnosis, and treatment of disease, for patient rehabilitation, and for improving health." (NIBIB, 2008) It represents the working definition for them. For many about the argument visit (Bronizino, 2000).

All the fields of science around the world never stop to advance. Everyday there is a new benefit and innovative results in science. As the others, the change in the biomedical engineering never stops also. So many studies have reviewed the recent and new trends in one or more of the biomedical specializations. Griffith et al has reviewed the impact of the development of electronics, optics, materials, and miniaturization on the evolution of the biomedical engineering (Griffith, 2001), (Bansi D, 2004), (Belenky V, 1991), (Ortalon, 2001) and (David Y., 2008). David has presented the trends in clinical engineering (David Y., 2008). Other works have developed trends in a subfield and in a certain country (Ohnabe H., 2006). Ohnabe has discussed the trends in rehabilitation in Japan. And so inner, some authors have written in one feature in a field of biomedical engineering (Hashino, 2006). Hashino has spoken about the trends in the use of robotics in medicine.

This paper is trial to highlight the advanced recent trends in almost all the fields within the biomedical engineering. It is better to introduce it with the definition and the applications of each field.

## II. BIOMEDICAL ENGINEERING RAINBOW

Figure I show the divisions of the discipline of the biomedical engineering.

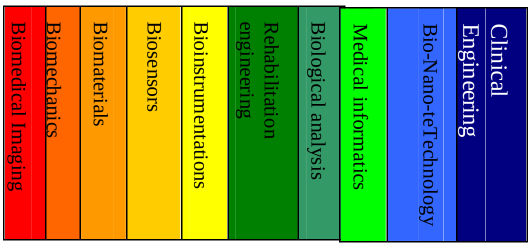


Figure I show the Biomedical Engineering Discipline

*Biomedical Imaging*

Regarding the biomedical imaging NIBIB defines: "Biomedical imaging methods open new ways to see the body inner workings, measure biological functions, and evaluate cellular and molecular events using less invasive procedures" (NIBIB, 2008).

*Biomechanics*

"Study the static and dynamics and fluid mechanics associated with the physiological systems" (Bronizino, 2000).

*Biomaterials*

"Design and development of biocompatible materials" (Bronizino, 2000).

*Biosensors*

"Detection of biologic events and their conversion to the electrical signals" (Bronizino, 2000).

*Bioinstrumentations*

"To monitor and measure physiologic events; involve the development of biosensor" (Bronizino, 2000).

*Rehabilitation Engineering*

"Design and development of therapeutic and rehabilitated devices and procedures." (Bronizino, 2000).

*Biologic Analysis*

"To detect, classify and analyze bioelectrical signals" (Bronizino, 2000).

*Medical Informatics*

“Of patient-related data, interpret results and assist in clinical decision making include expert systems and neural networks” (Bronizino, 2000).

*Bio-Nano-Technology*

**“**It is the intersection of biology and nanotechnology. Bionanotechnology is a broad and somewhat vague term which is sometimes used interchangeably with nanobiotechnology, which usually refers more specifically to the use of nanotechnological devices for applications in biotechnology” (Wikipedia, 2008)

*Clinical Engineering*

“Design and development of clinically related facilities, devices and procedures” (Bronizino, 2000).

## III. RECENT TRENDS AMONG THE BIOMEDICAL ENGINEERING SPECTRUM

In this section the trends in each field will be presented.

1. *Medical Imaging*

**Fusion imaging**

To overcoming the problem of looking at the anatomical image and the functional image by different medical specialists and cancel the need of their meeting, a trend is towards fusing the functional and the anatomical images together. This technique has advances the field of tumor detection by improving the level of precision and details such emerging the image of the PET scan (Functional) and CT scan (anatomical). The process is software-based (Hellman S., 2004).

**Emission computed tomography (ECT**)

Coming over the traditional CT Technology, is the Emission computed tomography (ECT). It is a shift towards imaging and exploring the molecular activities rather the physical parameters. It falls into two directions:

- Single photon emission computed tomography (SPECT)
- Positron emission tomography (PET**)**

This technology adds many benefits in myocardial imaging (Keyes JW, 2008 )

**Hybrid imaging modalities**

Many in one are benefit-full in terms of multiplicity and synergism. Thus, there is trend towards developing hybrid modalities PET/CT, SPECT/CT, PET/MRI and X-ray/MRI. (Pelc., 2003)

**Trends in MRI**

*FMRI:* measuring brain activities during cognitive, motor, and sensory operations by monitoring changes in blood-oxygenation level (BOLD) which indicates the amount of activities in the brain (Wikipedia/FMRI, 2008).

**“***Diffusion MRI* is a magnetic resonance imaging (MRI) method that produces *in vivo* images of biological tissues weighted with the local micro structural characteristics of water diffusion”. It is has been proven to be the most effective means of detecting early strokes (wikipedia/tensor imaging, 2008).

*Cardiac Imaging:* a special MRI technique for the assessment of the function and the structure of the heart and the cardiovascular system. It provides more accurate pictures of the heart than does the traditional MRI. It can capture heart beat in real time by imaging up to 50 frames/second in a sequence triggered by ECG and allows doctors to see coronary arteries in enough detail (wikipedia/Cardiac MRI, 2008).

*Lung imaging*, the non-ionizing signal is a powerful advantages of the MRI that eligible it to be preferred in imaging the body organs and their functions. Now it is used to image the lung. It is a sharp transition from the chest x-ray and nuclear medicine techniques. It will be helpful in the diagnosis of lung diseases and better tool for lung functional imaging. This technique was faced by the challenge of the few amount of water in the lung. Thus the inhalation of hyperpolarized gases or gadolinium aerosol that responds to the MRI was the solution (Zaporozhan, 2009).

**Ultrasound Development Trends**

*High intensity focused ultrasound (HIFU)* could be used to heat and destroy pathogenic tissue. And it can be used in the therapy of the prostate cancer (François J**.,** 1999).

*Volume Scanning* is used to develop 3D images and it can be used in the cardiology, obstetrics, and gynecology (Thomas R, 2006).

*Endoscopic Ultrasound (EUS*)is helpful in the detections of many types of cancers (pancreatic, gastric, rectal, and lung (Gavin C., 2007).

2. *Biomechanics*

It will be discussed, the problem related to the movement which may occur as a reason of the neuralgic problems or the muscuskeletal problems

**Neuralgic problems**

The efforts that has been dine to compensate this problem is the development of the Neuromuscular Electrical Stimulation (NMES) in which an electrical signal is applied using surface electrodes to generate the action potential at the end of the story and making muscle contracts. For the rehabilitation of the paralyzed to walk as the normal it is critical to stimulate many muscles that build up the process of the walk. The improvement activities in this device are done with the aid of the artificial intelligent tools (i.e. artificial neural networks ANNS). (Ortolan, 2001.)

Also efforts are done in the area o rehabilitation of the tact sensation by developing electron-tact stimulation using skin electrodes.
The problems of communication caused by the head injuries are overcame by developing a communication device that is based on the light and the eye movement. (Ortolan, 2001.)

**Muscuskeletal problems**

The biomechanics advances the field of the ergonomics by studying the biomechanics of the spinal cord in order to develop models that help understanding and developing lifting instructions (Ortolan, 2001.).
Also there are many efforts in the dealing with osteoporosis (a metabolic disease affect the density of the bone) by using ultrasound (Ortolan, 2001).

3. Biomaterials

**Bone regeneration**

The biomaterial community need to find material not only replaced damage tissues, but also at regenerate them and also able to elicit a specific response from the host, being at same time bioresorbable. Calcium phosphate based materials are the best fitted candidates for specific area bone regeneration. They are not only biocompatible, bioactive, and can be considered as bioinspired materials, since nonstoichiometric hydroxyapatite is the mineral phase of bone and also can be bioresorbable (Ginebra P., 2007).

4. *Biosensors*

**Biosensor based on Langmuir-Blodge films**. Langmuir- Blodge films are formed by dispensing a small quantity of an amphiphilic material dissolved in a volatile organic solvent onto the surface of purified water (sub-phase). Biosensor based Langmuir-Blodge films is important method for immobilization of enzymes. Bansi D. |Malhorta et al used Langmuir- Blodge films for immobilization of developed galactose oxidase (GaO) lactase (B-galactosidase ( B-Gal)) and glucose oxidase (GOX) (Malhorla, 2004).

5. Bioinstrumentations

One of the new trends in the field of medical instruments is the **intelligent medical instruments.** Papp.z et al "drew their own experience in the development of intelligence EEG recorders and analyzers. They focus on the integration of the knowledge base with numerical database and the algorithms within the unified real-time control structure of measuring system. Possible alternatives are presented for implementation of both conventional data processing and knowledge-based data processing" (Papp Z., 1988).

6. Rehabilitation Engineering

**Robots development**

Trends are towards the use of **robotics** in home rehabilitation (MIchille J, 2008).

**Artificial organs**

Also there are many trends towards developing many rehabilitated devices such as artificial heart, Liver, Blood, Kidney and Cochlear implant.

*7. Clinical engineering*

**Technological forces**

The technological advancement in the health environment, presents advanced trends in clinical engineering and roles for the clinical engineers. The emerging of the human genome mapping to the area of the preventive medicine, the amazing outputs of the nanotechnology and nano-scale devices and the capacity, the capability of the computer and the information technologies represents a challenge for the clinical engineers to change and adapt (Grime S. 2003).

**Systematic trend**

The shift from discrete devices to the connected technologies adds a new trend for the clinical engineers for more thinking about the system (i.e. connected technologies) approach to accomplish a certain process (Grime S. 2003 ).

**The interface with information technology**

The appearance of many biomedical technologies that rely on the applications of the information technologies (ITs) such as PACS and telemedicine technology, introduced interconnection between the role of the clinical engineer and the information technologist . Thus the need of determining the boundaries between the practices of these two professionals is critical (ACCE 2001). Also the development of the information and communication technologies advances the area of the remote service and advances the diagnostic services for the biomedical technologies through the application of knowledge engineering and artificial intelligence principles.(Blumbag 2004).

**Bridging the gap of the developing countries**

The challenge of bridging the gap of the developing countries in the acquisition and the utilization of the biomedical technologies is still mastering the clinical engineering yard (Frize,200).

**The Challenge of the safety**

All over the world it is a fertilized environment of research, learning and knowledge sharing, that is for better determination root causes and the rationales behind the use error (ACCE 2001)

**Quality programs and accreditation**

It is strongly needed, the assistance of the clinical engineering department (CED) to comply with the accreditation programs, quality systems and even the requirement of the excellence or developing new quality activities that better fit the CED (Grime, 2003).

## VI. CONCLUSIONS

This paper tried to collect the advanced trends in biomedical engineering. For The majority of the field within the biomedical engineering, the main trends have been presented. Because of the rapid development of the science, updating the topic like the advanced trends is recommended.


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